A National Program of Research for

FOOD SAFETY

Prepared by

A JOINT TASK FORCE OF THE
U. S. DEPARTMENT OF AGRICULTURE
AND THE STATE UNIVERSITIES
AND LAND GRANT COLLEGES

FOREWORD

The United States Department of Agriculture and State Agricultural Experiment Stations are continuing comprehensive planning of research. This report is a part of this joint research planning and was prepared under recommendation 2 (page 204, paragraph 3) of the National Program of Research for Agriculture.

The task force which developed the report was requested to express their collective judgment as individual scientists and research administrators in regard to the research questions that need to be answered, the evaluation of present research efforts, and changes in research programs to meet present and future needs. The task force was asked to use the National Program of Research for Agriculture as a basis for their recommendation. However, in recognition of changing research needs, it was anticipated that the task force recommendations might deviate from the specific plans of the National Program. These deviations are identified in the report along with appropriate reasons for change.

The report represents a valuable contribution to research plans for agriculture. It will be utilized by the Department and the State Agricultural Experiment Stations in developing their research programs. It should not be regarded as a request for the appropriation of funds or as a proposed rate at which funds will be requested to implement the research program.

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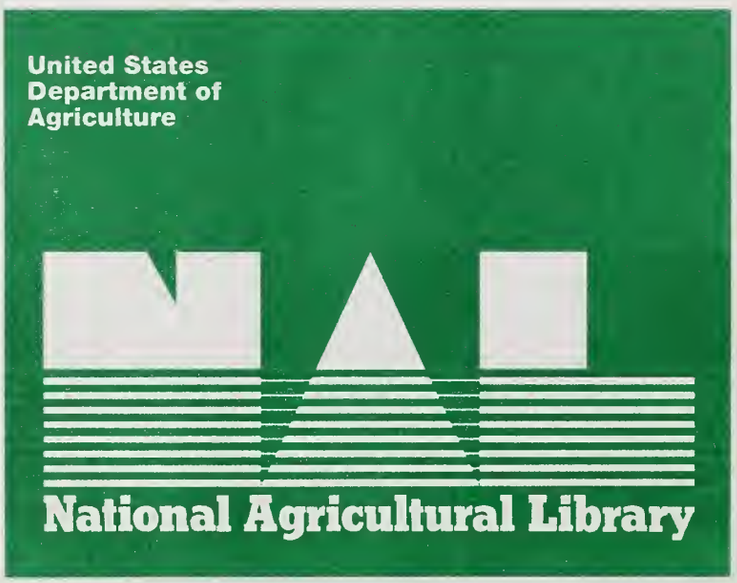
This report has been prepared in limited numbers. Persons having a special interest in the development of public research and related programs may request copies from the Research Program Development and Evaluation Staff, Room 318-E Administration Bldg., USDA, Washington, D.C. 20250.



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HIGHLIGHTS OF THE REPORT

The public expects agriculture to produce and market foods that it can buy with confidence. This means food that is wholesome and free from harmful pesticide residues, disease agents, or toxic substances. Research to aid in achieving a wholesome and safe food supply is an essential part of the larger goal to protect consumer health and improve nutrition and well-being of the American people.

Food safety research can have direct health benefits by lowering the incidence of acute, fatal, and chronic illnesses and toxicoses. Economic benefits to the farmer also result by decreasing the risk that some food products can become unacceptable to the public. A sudden loss in confidence in the wholesomeness of a food crop can ruin a farming industry. Consumers benefit by having less income loss from sickness and greater satisfaction in eating quality of their food. For Government agencies responsible for action programs, such as meat and poultry inspection, pesticide regulations and food safety, research is absolutely essential to back up their regulations and enforcement activities, as well as introduce efficiencies in operations.

The projected effort for food safety research is only 1.9 percent of the 1977 combined USDA, SAES research program. Like projections for food and nutrition, this food safety effort is small in proportion to its potential benefits and may be inadequate in terms of needs to achieve national goals. However, it is recognized that other governmental research activity in this field may equal or exceed that in the combined USDA, SAES program.

Research of highest priority relating to toxic pesticide residues from agricultural sources are:

(1) safe levels of residues on or in farm products
(2) metabolic fate of pesticides
(3) effects of processing, handling, and storage on toxic residues

Research of highest priority relating to protection of food supplies from harmful microorganisms and naturally occurring toxins are:

(1) ecologic and epidemiologic patterns of zoonoses
(2) toxic products of molds other than Aspergillus flavus
(3) destruction of food-borne pathogens
(4) significance of food-borne viruses
(5) microbiology of prepackaged and preconstituted foods

The Task Force has not recommended increases for RPA's 701 and 702 above the levels recommended by the Long Range Study. However, the Task Force

does recommend a 1977 level of effort for development of procedures, equipment, and facilities for use in red meat and poultry inspection programs considerably above that apparently contemplated by the Study.

INTRODUCTION

A study on the long-range needs for agricultural research was made by a joint 12-man USDA-SAES Task Force and published in 1966 as A National Plan for Agricultural Research. The report emphasized the need for improving agricultural technology, includes a system of classification of research in broad Research Problem Areas (RPA's), and recommends the degree of effort to be directed to each RPA to fulfill these needs over the next decade.

The Joint Task Force that made this long-range study recommended that the Agricultural Research Planning Committee (ARPC) designate research subject matter areas which need study and evaluation in order to develop a more systematic and continuing mechanism to facilitate joint research program planning, evaluation, and coordination. The Task Force also recommended that these subject matter areas be studied by joint USDA-SAES-Industry ad hoc interdisciplinary committees of scientists and that the chairman of the Experiment Station Committee on Policy (ESCOP) and the Department's Director of Science and Education should jointly appoint the special task forces.

The responsibilities for making the in-depth studies of the 91 RPA's were divided among 32 joint State-Federal Task Forces. The area of responsibility for this Task Force is in Goal VII and includes RPA 701 (Insure food products free of toxic residues from agricultural sources), 702 (Protect food supplies from harmful micro-organisms and naturally occurring toxins), and that portion of 707 (Prevent transmission of animal diseases and parasites to people) that involves the development of procedures, equipment, and facilities for use in red meat and poultry inspection programs. In this report it is labeled RPA 707-D.

The USDA members and special advisors to this task force were appointed by Assistant Secretary George L. Mehren; members representing the States were appointed by Dr. Roy L. Lovvorn, Chairman of ESCOP.

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A subcommittee on Research Programs and Facilities of the ARPC made recommendations as to the most effective division of research effort between the USDA and the SAES. Their manpower recommendations and allocations were based upon the projections in the long-range study. This task force has noted the allocations but has not made separate recommendations other than to comment on the inadequacy of the current research effort. The following report includes comments on the present program and indicates areas of research that need emphasis.

ROLES AND GOALS OF FOOD SAFETY RESEARCH

Research in food safety is essential in providing a satisfactory food supply for the United States and the world. Providing safe food for mankind has been one of the axiomatic goals of civilization. It was the objective responsible for the promulgation of man's oldest religious laws and has been one of the primary reasons for the existence of governments among men. The vendors of foods have been subject to regulation by either religious or civil government since prehistoric times, and meat inspection laws were promulgated in North America as early as 1706.

The food available to the American consumer is of great variety, is carefully processed, and is among the highest quality and wholesomeness available to consumers anywhere in the world. Nevertheless, it is essential to the public interest that a continuing and responsive program of food safety research will identify and develop pathways to help assure that the health and safety of consumers will continue to be protected to the maximum extent.

As food technology has developed, and as more complex systems of manufacture and distribution have evolved, the necessity for bringing advanced methods of scientific inquiry to bear on food safety has become ever more evident. The United States has extensive regulatory programs directed to food safety and wholesomeness. These programs need to be supported by the kind and scope of research effort indentified in this report. This kind of research is now recognized as an essential part of the goal of protecting consumer health and improving the nutrition and well-being of the American people.

Benefits of this research are manifest in many ways. The resulting lowered incidence of acute, chronic, and fatal illnesses and toxicoses has direct and substantial economic and social benefits. The research provides a sound basis for regulatory and enforcement activities concerned with food safety and wholesomeness. It safeguards the farmer by decreasing the risk that some food crop may suddenly become unacceptable to the public. Export markets are affected as easily as the domestic market when uncertainty exists as to the disease carrying or toxic potential of a food product.

The significance of mold metabolites in our food supply is just beginning to be understood. Microbial contamination and its effects are old problems that still are far from being completely under control.

More than half of the identified foodborne disease outbreaks are caused by Staphylococcus. Salmonella is the second most common foodborne disease agent. There are approximately 20,000 human isolations of Salmonella annually reported to the National Communicable Disease Center. A great many cases are unreported. It is conservatively estimated that the actual

number of foodborne and waterborne disease outbreaks are at least 10 to 20 times larger than the reported number. No one knows exactly what toll other foodborne infections or intoxications now exact from our populace. Where dangers exist. they must be overcome. The benefits that will accrue to mankind will be worth the effort required.

A PROGRAM OF RESEARCH TO INSURE FOOD PRODUCTS FREE OF TOXIC RESIDUES FROM AGRICULTURAL SOURCES (RPA 701)

Situation. Toxic residues from agricultural sources found in food have their origin, for the most part, in the use of pesticides during production of livestock and crops. Insecticides or fungicides applied directly to growing plants may remain on the surface or be absorbed into plant tissues. Herbicides applied to soil can be absorbed by growing plants. Animals may accumulate pesticides in their tissues from consumption of contaminated feed or water or from the application of pesticides to the animals for control of flies or other pests. These pesticides also pass through the animal into milk and eggs. Therefore, most of the research that is done to increase efficiency of production by protecting crops and livestock from diseases, insects, weeds, or other hazards, must take into account the need for producing food that is free of toxic pesticide residues. Thus, under Goal II there is research underway to develop safer pesticides or non-chemical methods of pest control which will have spin-off value for food safety.

Pesticides are the most common sources of toxic residues in food, but radionuclides from fallout and some chemicals used as food or feed additives contribute to the problem. Nitrates in pasture grasses have been involved in livestock intoxications, but their involvement in human illness is open to question except perhaps with small infants. Certainly this problem needs further investigation.

In order to provide consumers with safe food, it is necessary to appraise with reasonable certainty the toxicity of pesticides to humans. Research on this problem is done with laboratory animals. Established tolerances are based on these tests and include a safety factor of considerable magnitude. Once tolerances have been established, there is need for dependable methods of insuring that foods meet the requirements. Research on this broad question includes methods of detection and methods of removal or detoxification. Research on the latter in turn requires research on the chemistry of pesticides, method of action, site of accumulation, and the interaction of pesticides and animal tissues. These interactions lead into the fields of biochemistry, toxicology, physiology, pharmacology, and pathology.

Great progress has been made in the development of highly sensitive and reproducible analytical methods for pesticides. This has included both chemical methodology and instrumentation. Much has been learned about the persistence of the commonly used pesticides in soil, water, and animal or plant tissues. The site and mechanism of action of several pesticides have been determined. Metabolites or decomposition products of a number

of pesticides have been isolated and identified. A great deal has been learned about the effects of processing on removal of pesticides, but progress in decontaminating feed or food has been slow.

Tolerances have been established under the Food, Drug, and Cosmetic Act for the safe use of many pesticides, but new information developed has required changes in tolerances for some. Further research may show that established tolerances for some pesticides should be lowered in order to maintain a suitable factor of safety to consumers or to reflect lesser residues resulting from changed patterns of use.

Current Program. Much of the research currently underway is concerned with determining the nature and extent of the problem. The research at the State Agricultural Experiment Stations consists principally of analyses to determine the amount of residues present in livestock and poultry products, and fruits and vegetables following the use of pesticides under controlled conditions. This research is also useful in obtaining clearance for use of pesticides. In addition, random samples of food from retail outlets are analyzed to determine the range and average levels of pesticides in food bought by consumers.

Research in this area by the USDA includes surveys to determine the level of pesticide residues or nitrates in surface and ground water and in livestock and poultry products, fruits, and vegetables; controlled feeding experiments to determine rate and site of accumulation of pesticides in animal tissues; relation of feeding and management practices to disappearance of pesticide residues from animal tissues; and the residue problems associated with post-harvest treatments to control stored-product pests.

Three agencies, the USDA, the SAES, and the FDA, conduct research on the following problems: toxicity studies with laboratory animals to determine safe levels of residues; effect of processing methods on removal or detoxification of pesticides or pesticide residues; metabolic fate of pesticides; and basic research on chemistry of pesticides.

The Food and Drug Administration does almost as much research in this area as the combined effort of the USDA and SAES. More than one-third of the effort in FDA is directed toward the development of improved methods for quick and accurate analyses.

Priority Research Needs. In order to insure the public of food products essentially free of toxic residues from agricultural sources, it is necessary to secure more information on the following eight specific questions:

1. What are safe levels of residues on or in farm products for human consumption or animal feed?

Research on protection under Goal II is expected to reduce the amounts of pesticides used and thus reduce pesticide residue problems, but the

monitoring program in livestock products, animal feeds, fruits, and vegetables must be continued and expanded because of the new developments in methods of application, harvesting, processing, and merchandising, and because of the new pesticides that will be developed. It is recommended that research be continued and expanded on toxicity of pesticides, level of residues following controlled experiments on methods of application or feeding, and on random sampling of feed and food in market channels.

2. What is the metabolic fate of various pesticides?

Research effort on this specific question is at a low level. More information on these metabolic pathways, in plants and laboratory animals, site of action, site of storage, and form in which excreted is essential in order to understand the problems associated with the safety of pesticide residues.

3. What is the composition of residues at harvest time?

As new pesticides are developed, they must be tested under controlled conditions and the residues that persist must be determined. It is not economical for industry to secure the data necessary for registration of chemicals used on minor crops; therefore, the SAES have supported this research under an inter-regional project financed with Regional Research Funds. Research on the weathering of pesticides is needed. It is known, for example, that heptachlor converts to heptachlor epoxide upon weathering and that dieldrin converts to photodieldrin. It is likely that many other pesticides also convert to compounds that are unknown or unrecognized at present. A full understanding of the residue problem is dependent upon a knowledge of the composition of the residue at harvest time.

4. What effects do processing, preparation, handling and storage procedures have on toxic residues and on the composition of residues at time of consumption?

At present, research on this question is concerned with the effects of washing, trimming or peeling, heat, vacuum, sonic vibration and time on the reduction of pesticide residues. This research should be expanded to include studies on the possibility that processing or other handling procedures may convert residues to other toxic compounds or detoxify the residues. This will require detailed studies on the breakdown products of various pesticides following various treatments.

5. How permanent are the toxic substances produced by the use of pesticides and what methods can be developed for removing them or reducing their concentration?

The major concern with respect to this question is the persistence of pesticides in soil or water. It is known that some pesticides persist for long periods in soil and that they find their way into fresh and salt water where they may be concentrated in the food chain. The ultimate solution to the problem appears to be the development of non-persistent or biologically degradable pesticides. In the meantime, research should be continued on soil and water treatment or management practices that will remove or inactivate the residues.

6. How can the ingestion of pesticides or other chemicals in animal feeds be reduced?

The solution to this question will depend to a large extent on the success of efforts to develop non-chemical methods of pest control and improved application of pesticides. This research is classified under Goal II. One area deserving special attention is the use of antibiotics and other feed additives as growth promotants in livestock and poultry feeds. Although these may not in themselves be hazardous to human health, they may stimulate the development of drug resistant microorganisms in animal tissues that could cause trouble in humans.

7. What are the opportunities for developing quicker and more accurate methods for monitoring pesticide residue levels in crop and livestock products including animal feeds?

In order to improve the monitoring program, it will be necessary to develop quicker and even more accurate methods for determination of pesticide residues. Since the FDA has assigned 44 SMY to this problem,there need not be more than a moderate increase in this program in USDA and SAES. As has been true in the past, it is expected that the USDA and SAES efforts will consist largely of adapting FDA methods to specific product and problem areas.

8. What are the effects of pesticides on human metabolism and nutrition?

Knowledge concerning the effects on humans of daily ingestion of small amounts of pesticides over extended periods is limited. Tolerances established by FDA are based on experiments with laboratory animals using an appropriate safety factor.

Most of the research on this question is being conducted by the Public Health Service through its epidemiological studies. These are intended to answer the question of the real impact of pesticides on man directly rather than extrapolation of data from animal studies.

Manpower Needs

SMY Previously Recommended by SAES/USDA

	1966	1972	1977
States	85	127	155
USDA	33	54	68
Total	118	181	223

For necessary research to answer each of the specific questions listed above, the following increases in SMY's by 1977 are recommended:

Problem	SMY	Problem	SMY
1	20	5	5
2	25	6	5
3	10	7	5
4	25	8	10

The total of these increases is 105 which equals the recommended SAES/USDA increase for RPA 701. By far, the greatest emphasis should be placed on research dealing with the metabolic fate and effect of pesticides and safe levels of pesticide residues in foods and feeds.

A Program of Research on Protection of Food Supplies from Harmful Microorganisms and Naturally Occurring Toxins (RPA 702)

Situation. "At present, the consumer cannot be completely assured of the safety of food prepared in or away from the home."1/ Large numbers of outbreaks of foodborne and waterborne diseases are reported annually. For the nine-year period, 1952-60, (Dauer, C.C., Public Health Reports, 1961, vol. 76, No. 10, pp 915-922) over 90,000 cases of such diseases were reported. This surveillance has been continued. The latest summary shows a total of 30,000 cases of foodborne diseases for 1966-67 (Morbidity and

1/ This quotation is taken from the report of the Task Force on Foods and Nutrition (page 17), which also has a deep interest and concern with food safety. Among their high priority research needs, they recommended research on "The effects of different storage, preparation, holding, and serving practices on the wholesomeness and safety of foods."

Mortality, vol. 17, No. 16, 1968). The etiology was unknown in 40 percent of the cases. The reported cases represent only a fraction of the total that actually occurred. Fifteen deaths were associated with the outbreaks in 1967. In the less severe cases, the total number of days lost from productive work constitutes a significant economic loss to the Nation.

The pace of change in the food processing industries is rapid and is characterized by the development of new foods, new equipment, new processes, new methods of preservation and expansion of shelf life, new packaging procedures and materials, mass production, and expanding markets. Many of these developments are a result of new food "wants" of the public for convenience foods which reduce cooking time and the labor of preparation, for different food tastes, and for any food any season of the year. Problems of actual or potential public health significance emerge as new foods prepared by new or modified methods of processing are marketed in increasing quantity. With the efficiency of modern food distribution, widespread disease could result before any attempt to recall a food would be successful.

Research in this area has provided a substantial fund of information that has been invaluable in controlling microbiological hazards; but there are basic questions of long standing still unresolved as well as some new ones generated by the recent advances and developments in food and feed processing. Thus, continued and, in most cases, escalated research efforts are needed to assure food and feed safety under the modern techniques of producing and harvesting raw materials, converting them to the new products demanded in today's and tomorrow's markets, and conveying them to the ultimate consumer.

The bacteria and protozoa most often identified as foodborne pathogens are: Salmonella serotypes and other members of the Enterobacteriaceae, Staphylococcus aureus, Clostridium perfringens, C. botulinum, and Endameba histolytica. Among other bacteria that are sometimes foodborne are Mycobacterium tuberculosis, Brucella sp., Vibrio parahemolyticus, Proteus sp., Pseudomonas sp., Arizona sp., Shigella sp., and Bacillus cereus.

Staphylococcus and Salmonella are the most common foodborne disease agents. Shigella and the Arizona are closely related to the Salmonellae and produce similar infections in man, but are less prevalent than Salmonella.

Clostridium botulinum is important not so much because of high frequency of illness, but rather because of extreme hazard to those who contract Botulism. Approximately 60 percent of all cases are fatal. Botulinus poisoning is caused by the development of a toxin when the bacteria grow in food. This toxin is the most toxic compound of biological origin known.

Poisoning from Clostridium perfringens is not regularly reported, but is believed to be a major source of gastrointestinal disease in this country

and may be a more important meat-borne disease than poisoning by Staphylococcus aureus; it has proved to be so in England. When ingested in large numbers, this microorganism produces a mild gastrointestinal upset with diarrhea malaise.

In Japan, Vibrio parahemolyticus causes 70 percent of the cases of gastroenteritis. It has not been reported in this country probably for two reasons: (1) the Japanese habit of eating raw fish is not common in the United States, and (2) laboratories do not look for this microorganism.

The presence of Mycobacterium avium in pork and poultry is quite general. Laboratory methods are not sufficiently definitive to ascertain whether some of these strains cause "atypical" tuberculosis in human beings. Whereas the human and bovine strains of tuberculosis have now been largely controlled "atypical" tuberculosis is still unsolved.

It should be emphasized that a great deal of information on incidence, pathogenicity, physiology, isolation, and identification procedures for foodborne pathogens is already available, and should be used as a base on which to build. In addition, reporting of foodborne diseases in the United States has been poor as contrasted with that of many other countries.

The role of foods in spreading viruses and in causing virus infections has not been well delineated. There is evidence of involvement of foods in transmission of infectious hepatitis, but lack of pertinent information on all aspects of the problem of viruses in foods is very striking.

Antibiotic residues are important to human health because some people are allergic to antibiotics and because the antibiotic residues may produce resistant strains of pathogens, which when ingested might cause disease not treatible by usual therapeutic means.

Since food safety is a problem from production through processing, marketing, storage, meal preparation, and storage of prepared foods, the Task Force set up the following five categories for detailed study:

A. Methods for freeing and protecting breeding herds and flocks from zoonoses.

B. Maintenance of microbiological safety in growing, harvesting, transporting, and storing raw agricultural products (fruits, vegetables, grains, livestock, and livestock feeds).

C. Maintenance of microbiological safety in processing, packaging, storing, and distributing foods and feeds.

D. Maintaining microbiological safety in handling foods during home and institutional storage and preparation.

E. Development and evaluation of techniques for sampling and laboratory analysis.

From a study of the long-range inventory records, the total of 60 SMY available in 1966 was distributed among subcategories A-E as follows:

Subcategory	SMY 1966		
	USDA	STATES	TOTAL
A	0.2	1.2	1.4
B	6.0	3.9	9.9
C	38.8	4.7	43.5
D	1.0	1.0	2.0
E	4.0	0.3	4.3
	50.0	11.1	61.1*

*The Task Force's own assessment of 1966 manpower in RPA 702 totaled more than 100. Difference in basis of classification can account for this discrepancy.

It should not be overlooked that this inventory of current research on food safety does not take into account either the intramural research or extramural support of other government departments such as Health, Education, and Welfare, and also Interior; for example, FDA has a primary mission in subcategory C, "Maintenance of Microbiological Safety in Processing, Packaging, Storing and Distributing Foods and Feeds." Their current inhouse program in this category is approximately 35 SMY. In addition, approximately 440 manyears are devoted to surveillance and compliance activities in the area of microbiological safety of foods. Much of the extramural research sponsored by HEW, even though providing only supplemental support to SAES projects, in total represents a very substantial segment of the overall resources devoted to this type of work.

In summary, it is evident that the research effort on food safety by these agencies may equal or exceed that in the USDA-SAES program. The need for coordination of these programs is now recognized and the establishment of a Federal Food Safety Committee has been proposed.

METHODS FOR FREEING AND PROTECTING BREEDING HERDS AND FLOCKS FROM ZOONOSES (RPA 702-A)

Situation. Zoonoses, diseases and infections that are naturally transmitted between vertebrate animals and man, involve the ecology of both animals and man. Ecology is the study of the relationship between living things and their physical, biological, chemical, psychological, and social environment. An ecosystem is composed of an organism, its genetic and physical makeup, and the environment in which it exists; it is in a constant state of flux. An infectious agent tends to have a habitat in a defined ecosystem in which the reservoir, vector and host circulate. Interaction between various elements in the environment puts pressure on an individual and an adaptive response occurs; if the response is inadequate, disease results. When man becomes involved in an ecosystem that contains a natural zoonosis, he may become infected and disease will possibly result, or he may alter the environment so that transmission is prevented. As man interferes with and manipulates the environment, he may even intensify opportunities for transmission of pathogens.

In recent years, advances in methods of controlling animal diseases, new agricultural and industrial practices, and changes in the environment in certain areas have contributed to shifts in epidemiologic patterns of some of the zoonoses. Brucellosis has changed from a disease of persons who drink raw milk from infected cows to one of contact and inhalation in meat packers and veterinarians; psittacosis has shifted from a disease of pet bird owners to an occupational disease of poultry-plant workers. Anthrax, once associated almost entirely with farming and a rural environment, is today more and more in industrial areas - from processing plants for animal hides or hair. Salmonellae once were considered primarily of rodent origin; then the human intestinal tract and excreta were established as sources of these enteric organisms, namely S. typhi and S. paratyphi; now epidemiological information and emphasis have shifted from humans to animals and suggest that animals are the most significant sources of Salmonellae.

Zoonoses that may be transmitted by the consumption of foods include: salmonellosis, staphylococcal intoxication, Clostridium perfringens foodborne illness, botulism, coli bacillosis, Arizona infection, brucellosis, tuberculosis, Q fever, trichinosis, pork tapeworm and cysticercosis, beef tapeworm, toxoplasmosis, anthrax, hydatidosis, pasteurellosis, Vibrio parahemolyticus infection, tularemia, balantidiasis, clonorchiasis, fascioliasis, fasciolopsiasis, paragonimiasis, sparganosis, parasitic eosinophilic meningoencephalitis, anisakiasis, gnathostomiasis, central European encephalitis, diphasic meningoencephalitis, lymphocytic choriomeningitis, and myiasis. Besides these diseases, other illnesses can be transmitted by contact with animals or meat products during processing. Examples of diseases spread by occupational contact include: anthrax, brucellosis, glanders, leptospirosis, pseudotuberculosis, tuberculosis,

contagious ecthyma, cow pox, psittacosis, Newcastle disease, pseudo cow pox. Many of these diseases are unimportant in the United States and the importance of others is limited or undetermined.

Animal populations generally are conceded to be the key reservoirs for maintaining zoonoses. Reducing or eliminating infections in our animal populations will break the usual pathways by which man becomes infected.

Excellent progress has been made for certain pathogens such as Salmonella pullorum, S. gallinarum, Mycobacterium tuberculosis, and Brucella sp. Man is little troubled now by transmission of these diseases to him from animals. However, there are many Salmonellae, Staphylococci, Clostridia, and other pathogens where little progress has been made in freeing herds and flocks from them. These deserve our attention if man is to make progress in preventing infections from zoonoses.

Current Program. The current research program in this area is very modest and is primarily in support of the development of tuberculosis and brucellosis testing programs in mammals and Salmonella testing programs in poultry. There is no current USDA research effort beyond that in RPA 211 which indirectly supports RPA 702. At least 6.5 SMY can be identified in the SAES research.

Priority Research Needs. Questions or problems involved in developing methods for freeing and protecting herds and flocks from zoonoses are listed below:

1. Provide continuous investigation and surveillance of ecologic and epidemiologic patterns of zoonoses.

2. Many infections and disease syndromes depend on multiple factors rather than just on the presence of pathogens in an environment. These multiple factors for many diseases are not well understood and further investigation is needed.

3. Continue to determine the modes of transmission of foodborne pathogens and fill in existing gaps of information. These should be based on sound epidemiological investigations and controlled studies. Evaluate changes in new animal husbandry practices and sanitation on the impact of disease transmission.

4. Continue to identify sources and reservoirs of food borne pathogens. The necessary laboratory and testing services will have to be available.

5. Continue to develop more rapid methods for detecting animal infections. Evaluate the efficacy of routine methods of examining

herds and flocks for infections, i.e., cloacae or rectal swabs, sampling excreta, blood testing, etc.

6. Study in detail environmental factors that allow foodborne pathogens to survive in an environment.

7. Salmonella typing services should be expanded in present locations and new laboratories should be established. This is a critical service for 90 percent of all Salmonella research.

8. Studies on producing Salmonella-free feed by means of controlled pasteurization during pelleting.

9. Studies on feasibility of interdicting transmission of Salmonella via the contaminated egg.

10. Studies of influence of environment and media on both antigenic structure and pathogenicity of Salmonellae, and other pathogens.

MAINTENANCE OF MICROBIOLOGICAL SAFETY IN GROWING, HARVESTING, TRANSPORTING, AND STORING OF RAW AGRICULTURAL PRODUCTS (RPA 702-B)

Situation. The maintenance of microbiological safety in raw agricultural products is fundamental to the delivery of safe products to consumers. Although subsequent processing may be counted on to reduce or eliminate contamination by harmful organisms in some cases, for most products it is essential that they be protected from contamination during growing, harvesting, transporting, and storing. Most of the current research in this area is now devoted to the problem of mycotoxin development in grain and oilseeds and the bulk of this effort is concerned with aflatoxin.

The existence of eight different mold metabolites designated as aflatoxins is now recognized. These are produced mainly by the Aspergillus flavus oryzae group of fungi. Aspergillus flavus and most other toxigenic molds are extremely common and can grow on a variety of natural substrates under a wide range of conditions. Aflatoxin B, the most toxic aflatoxin, is also one of the most potent carcinogens known. It is only one of a great number of toxins which are elaborated by fungi that infest stored agricultural products. Conditions of high temperature and moisture favor attack by these microorganisms.

On farms, health hazards of microbiological significance center chiefly upon the production of meat, poultry, milk, and eggs. Animals are important reservoirs of Salmonellae and Clostridium perfringens; they become

infected from feed and other environmental contacts on farms. The use of antibiotics as a growth-promoting factor in animal feed is reported to be associated with the emergence of Salmonella serotypes resistant to antibiotics used in feed. An increasing staphylococcal problem in the dairy industry stems primarily from the continuous use of antibiotics for the control of bovine mastitis. The practice of feeding antibiotics to livestock and poultry has raised questions as to the effects of antibiotics on microbial ecology, resistant flora, and possible human infection.

Other farm related health problems include the contamination of grains, fruits, and vegetables with enteric organisms from sewage-contaminated water, from fertilizers, and from infected workers who have a poor knowledge of personal hygiene, particularly when facilities for hygiene are lacking on the farm.

Besides the problems of transmission of the zoonoses on farms, the problem intensifies when animals are transported to market. Several studies have shown that Salmonella infection rates in cattle and swine may be low on the farm but are high after the animals have been shipped to market and held in holding corrals for a few days. The stresses created by the absence of food or water, handling, crowding, cold, and transporting may trigger a mechanism that changes an infected but nonexcreter of Salmonellae into an excreter. This raises the question about the effect of stress in animals on disease resistance and on the frequency with which animals in transit are responsible for the spread of infection.

With the growing complexity of the road traveled from farm to ultimate consumer, many other problems of food safety now demand research attention. The isolation of Salmonellae from plant materials such as oilseed meals raises the question of how and where such products become contaminated. Recently, strains of paracolon-like bacteria isolated from cases of infant diarrhea have been shown to be plant pathogens as well, a finding that poses many new questions for research.

Current Program. Much of the research in this sub-category is devoted to developing new processes for eliminating aflatoxins, and it is therefore difficult to divide this research between areas 702-B and 702-C.

Considerable effort also is being devoted to methods of growing, harvesting, and handling crops to insure freedom from mycotoxins. There is a significant program on the relationship of post-harvest handling, conditioning, and storage practices on aflatoxin development in peanuts, cottonseed, rice, and corn. A small related effort comprises studies on the role of insects in spreading contamination in stored products and on methods for sanitizing vegetables at the time of harvest.

Priority Research Needs. The Task Force recommends that the current level of effort in this area (702-B) be continued and expanded but also redirected, in part, to other problems in this area of study. Some high priority research problems are:

1. The toxic products of molds other than Aspergillus flavus.

Emphasis should be placed on new genera and species, and new toxins by means of:

(a) Investigations of feeds and foods suspected of being involved in physiological and/or pathological disorders, followed by detection, isolation, and identification of fungi involved, and identification and detection of toxic substances.

(b) Studies on acute vs chronic effects in farm animals and humans with emphasis on long term - low concentration exposures.

(c) Establishing relationships of findings in experimental animals to the effects in mature farm animals and humans. The basic problem in all of this mycotoxin research is to delineate the dimension of the problem in humans.

The work should also be directed to establish possible control procedures that would be useful in food and feed processing. In these research efforts on mycotoxins, there is need for toxicology centers to provide the team approach: mycologist-taxonomist, biochemist, toxicologist, pathologist, and others.

2. The effect of stresses on farms and during transportation of livestock on infection and cross contamination.

3. The role and importance of insects, birds, rodents, feed, humans, and other factors in distributing harmful microorganisms to crops and livestock.

4. Reevaluation of the use of antibiotics in feeds with respect to the relative value of increased growth rate and increased numbers and types of resistant bacteria in the environment.

5. Evaluation of the effect of altering diet during feedlot stay upon the stress of animals and their resistance to microbial diseases.

MAINTENANCE OF MICROBIOLOGICAL SAFETY IN PROCESSING, PACKAGING, STORING, AND DISTRIBUTING FOODS AND FEEDS (RPA 702-C)

Situation. FOODS Problems of actual or potential public health significance emerge as the pace of technology and developments in the food processing and distribution system quickens.

Incoming raw ingredients, particularly animals or products of animal origin, may contain Salmonellae, C. perfringens, or other food-borne pathogens. These ingredients may contaminate workers or equipment that subsequently contact other foods. Long after the original source is gone, the organisms may linger in the plant environment and eventually contaminate other foods. During processing, any factor that acts selectively against any component of a mixed microbial population will change the comparative distribution and specific dominance of organisms within that population, and often in an unpredictable manner. Thus, pathogens may be encouraged. There are many examples of new developments in food processing that have led to outbreaks of human disease. For example, botulism from lightly smoked and vacuum-packed fish; salmonellosis from cake mixes containing unpasteurized dried eggs; salmonellosis from turkey and pork rolls; staphylococcal intoxication from dried milk and cheese, salmonellosis in instantized dry milk, and salmonellosis caused by a food supplement containing yeast and cottonseed protein.

In recent years, an outstanding achievement has been the development of in vitro methods for the detection of staphylococcal enterotoxin. This has resulted in the availability of a tool to use in screening foods for the presence of enterotoxin and to elucidate the various environmental factors affecting the production of enterotoxin. Work in USDA laboratories has provided information on enterotoxin development in meats.

In regard to control of Salmonellae, the USDA work on egg pasteurization has been very useful; and there has been recent work on growth and survival of these organisms during the manufacture of cheese. The development of better testing methods and more efficient surveillance of cases at CDC, USPHS, has created an increased awareness of the problem of Salmonellae in all types of raw and processed foods and made possible the detection of outbreaks that otherwise could go undetected.

There have been some very substantial gains in information concerning the incidence of Clostridia in raw foods and in the food processing environment, on heat resistance of certain strains as related to destruction and control of these organisms, and on factors influencing their growth in foods.

FEEDS Conventional methods of rendering should destroy vegetative cells from feed ingredients; however, feed ingredients and finished animal feeds sometimes contain pathogens such as Salmonellae. Recontamination of

finished products by direct or indirect contact with raw ingredients are the major source of these organisms. Workers, vectors, birds, processing waters, or delivery vehicles also contribute to contamination of the products. The distribution of Salmonellae in feed and feed ingredients is nonhomogenous and causes additional problems in sampling and interpretation of laboratory findings.

Current Program.

Nature of Research

Substantial research activity is in progress on the control of microbiological hazards during the processing and subsequent storage of foods and feeds. This research is intended to provide information on the destruction or control of microorganisms during processing, the elimination or minimizing of subsequent contamination of foods and feeds and the limitation of growth of the survivors or contaminants during the storage period between processing and ultimate consumption.

In these studies, attention is directed toward the common organisms involved in food intoxication and food-borne infection including Staphylococci, the spore-forming anaerobes, i.e. Clostridium botulinum and Clostridium perfringens, and the Salmonellae and other enteric pathogens. Of particular concern are the foods of animal origin such as eggs and egg products, dry milk and cheese, further processed poultry and cured meat products, as well as fresh poultry and fresh meats.

Basic studies in part involve investigations of the effects of processing and preservation techniques on microorganisms including the mechanism of injury by heat and other lethal agents and factors influencing the subsequent recovery of bacteria; the inhibition of spoilage and food poisoning types of bacteria by normal components of foods as well as by certain additives; and effects of various segments of food flora on growth and/or toxin production.

Priority Research Needs. The following is a listing of the priority research needs for RPA 702-C, Maintenance of Microbiological Safety in Processing, Packaging, Storing, and Distributing Foods and Feeds.

1. Factors affecting destruction of food-borne pathogens on raw materials and finished products. New production, processing, and packaging techniques necessitate reexamination of this area of work.

2. Ecology of Salmonella serotypes and anaerobes in processing plants.

a. Salmonella and other Enterobacteriaceae.

Besides much more information on the ecology of this group, the degree of importance of human carriers in processing plants needs additional study.

b. Anaerobic sporeformers.

For the various types of Clostridium botulinum and Clostridium perfringens, investigations are needed on the ecology, physiology, and biochemistry of these organisms.

3. Significance of food-borne viruses. The primary need here is for better methods of isolation and enumeration of viruses in foods. This recommendation is also made under RPA 702-E.

4. Research Questions on Feeds.

a. The extent of contamination by Salmonellae (and other pathogens) in feed ingredients and in finished feeds.

b. Terminal destruction of Salmonellae (and other pathogens) in rendered products and in finished feeds.

c. Methods of plant construction, equipment, layout, and process operational procedures to minimize cross-contamination.

d. Prevention of recontamination from various vehicular transporters of feed.

MAINTAINING MICROBIOLOGICAL SAFETY IN HANDLING FOODS DURING HOME AND INSTITUTIONAL STORAGE AND PREPARATION (RPA 702-D)

Situation. In the United States, 400,000 food-service establishments serve 100,000,000 meals daily. Eighty-two percent of these meals are served in public eating establishments, the remainder are served in institutions. Even a larger number of meals are prepared in homes.

Food preparation is in a transition period between traditional use of basic ingredients and increased use of prepackaged frozen, ready-to-cook, or preconstituted, (convenience) foods. New energy sources, such as microwave cooking, are also receiving considerable interest.

Another rapidly expanding method of food service is vended foods. They are now widely used in schools, colleges, hospitals, factories, and other places. Public Health Service ordinances cover such phases as permits, design, maintenance of operation, inspection of vending machines, and food service establishments. The Public Health Service suggested that the

ordinances be adopted by jurisdictions having established food service sanitation programs. Vended foods are, however, available in many other places. A recent survey indicated that a link is still needed between regulations and the food service industry. The latter needs more information on the use of this type of food service. The kinds of vended foods are still changing and increasing. Much more interdisciplinary research is needed to assure both the microbiological safety and nutrient value of such foods.

Foodborne hazards commence when foods enter the kitchen. Some foods, particularly those of animal origin, may contain pathogens such as Salmonellae and Clostridium perfringens. Additional contamination may occur as the foods are prepared, either from workers (Staphylococci, Salmonellae) or as a result of cross-contamination of foods from raw ingredients. Thorough cooking can destroy vegetative bacteria, viruses, and parasites in foods but not all spores. Proper refrigeration of incoming foods, prepared foods, and leftovers is essential to prevent multiplication of pathogenic microorganisms.

The safety of food handling in homes and food service establishments is complicated by the prior treatment or lack of it in the incoming supply. Terminal sterilization of foods cannot be performed for the vast majority of food items; closed processing systems, as in the case of milk, cannot be used; food-preparation operations include numerous food products and processes in many establishments with millions of food workers who, in some cases, are unaware or indifferent to safe food-handling techniques.

Priority Research Needs. Following is a list of the priority research needs of RPA 702-D, maintaining microbiological safety in handling foods during home and institutional storage and preparation.

1. Ecology of bacteria and viruses in home and institutional food preparation.

a. Salmonella and other Enterobacteriaceae.

Much more research-based information is needed on the multifaceted aspects of the epidemiology of this group.

b. The incidence and importance of other bacteria, such as Proteus, Pseudomonas, and Vibrio parahemolyticus in home and institutional food preparation in this country should be investigated.

c. Food-borne viruses.

Much less information is available on the role of foods in the spread of viruses than of bacteria. The procedures used in home preparation of foods are probably more conducive to survival of viruses than commercial processing of foods.

2. Microbiology of prepackaged and preconstituted foods at times of: (a) purchase, (b) after different holding temperatures, (c) after cooking, and (d) after holding cooked foods at different temperatures.

DEVELOPMENT AND EVALUATION OF TECHNIQUES FOR SAMPLING AND LABORATORY ANALYSIS (RPA 702-E)

Situation: In order to determine whether a food is safe microbiologically, it is essential to be able to isolate, enumerate, and identify bacteria, viruses, molds, yeasts, protozoa, and other parasites. Virtually all procedures now in use need to be improved, either to increase reliability and sensitivity, or to simplify and shorten the time required to obtain a result.

All agencies and scientific committees having an interest in microbiological safety of foods have considered methods to be a major problem. For example, the NAS-NRC Food Protection Committee said in 1965 "Determination of the types and levels of microorganisms in foods depends on the availability of methods that yield reproducible results of known specificity and sensitivity. Present methods have generally been adapted from diagnostic microbiology without adequate evaluation, or are based on standard methods for examination of water and milk. They are not always well suited to the range of foods encountered in the investigation of disease outbreaks, or in surveys of market products."

The IAMS International Committee on Microbiological Specifications for Foods has recognized the need for standardization of microbiological methods as a prerequisite for international microbiological standards and specifications.

The problems of methodology are complex because each specific pathogen has its own peculiar requirements of nutrition and environment. Furthermore, the nature of each food or feed has an effect on the method. Basically, microorganisms must be isolated before they can be identified and enumerated. For some agents this requires artificial media. For others, it requires living host tissues. Identification requires multiple testing for the isolated strain. In any such biological system, each step is affected by many factors, not all of which are known. The result has been the development of a multiplicity of poorly tested procedures. For some agents, there are no methods at all; there is some evidence that there are food-borne disease agents unidentified because of lack of methods.

Standard procedures for such tests are far too time-consuming for practical application to the testing of foods in commerce. All too often, shipments

of perishable products are sold and even consumed before microbiological tests have been completed. Those few rapid methods that have been developed are not sufficiently precise.

Standard procedures are so complicated and expensive that in many instances they are not used routinely.

Little attention has been given to sampling procedures in food microbiology. The very uneven distribution of bacteria in foods requires a carefully planned program each time samples are taken for analysis. Food microbiologists have very few criteria on which such sampling can be based.

Current Program. Currently it is estimated that about 10 percent of the SMY available in RPA 702 is devoted to research effort on the development and evaluation of techniques for sampling and laboratory analysis. The main effort involves methodology on mycotoxins, Salmonella, Shigella, and Arizona. Very little or no effort has been identified as methodological research on the other microorganisms involved.

Priority Research Needs. The adequacy of the available methods and the needed research are discussed under each of the agents involved.

Staphylococcus: Better methods of preparing antisera, and methods for rapid extraction and detection of the toxin produced by these organisms are needed. Research is also needed to determine the nature of the heat damage which makes them unable to grow on ordinary selective media.

Salmonella, Shigella, and Arizona: Current methods for determining the presence of these organisms on food are inaccurate and time-consuming. Isolation methods for Salmonella must stimulate the growth while inhibiting the often more numerous normal flora. This balance between stimulation and inhibition is precarious, and is further complicated by difficulties in recovering Salmonella from foods that have been subjected to drying, freezing or heating. Because of these factors, many of the existing methods are emperical, and inadequately evaluated.

Clostridium botulinum: Determination of the presence or absence and of the nature of the botulinus toxin is a time-consuming procedure requiring from one to several days and the use of experimental animals. Meantime, the question as to whether a given lot of food is hazardous is undecided. A rapid specific serological test for the presence of botulinus toxin in a food is needed. Methods for detection of the organism itself are unsatisfactory. Studies are also needed on the genetic relationship of toxigenic and nontoxigenic strains.

Clostridium perfringens: Clostridium perfringens is rarely reported as a causative agent for illness because of the difficulty of identifying the

strains responsible for the disease. New methods for sampling and storage are also needed because the cells of this microorganism die so readily in food samples.

Vibrio parahemolyticus: There is a possibility that Vibrio parahemolyticus may be found in products prepared by a salting process; however, no one has investigated this possibility in this country. The tests have only recently been developed and must be tried in this country before they can be an accepted part of food safety control.

Miscellaneous Diseases: The methods in use for the less common zoonoses are long and involved. Many of them require animal inoculation. Quick and easy methods are simply unavailable for these: Listeria, Leptospira, Pasteurella, Brucella.

Food-borne Viruses and Rickettsia: More than half of the reported disease outbreaks associated with foods are of unknown etiology. There is strong suspicion that most of these are filterable viruses or Rickettsia. Of these, the only ones readily identifiable (by symptoms rather than by isolation) are Q fever and viral hepatitis. Generally speaking, viral and rickettsial agents cannot be isolated from foods using methods now available.

Endameba histolytica, the cause of amebiasis, is the most important intestinal protozoan of humans. It is worldwide in distribution, and many surveys have shown that the incidence in the United States is at least ten precent. The cysts are quite resistant and can survive in water and food. Standard procedures for identification of this protozoan have long been available, and should be carried out whenever efforts to improve sanitation in processing plants and food distribution centers include examination of food handlers.

Mycotoxins: There are known to be a wide variety of toxins from molds and related microorganisms for which there are no methods of analysis. Before assessment of the importance of these toxins in agricultural commodities is possible, it is essential that methods be developed for their detection and measurement.

Dead, dying, diseased, and disabled animals: The methods for determining whether a piece of tissue came from a healthy animal, from one that died other than by slaughter, or from a sick or disabled animal need improvement and standardization. Expansion of Federal inspection into intrastate plants will increase the need for such tests.

MANPOWER NEEDS (RPA 702)

SMY Previously Recommended by SAES/USDA

	1966	1972	1977
States	10	30	40
USDA	50	70	80
Total	60	100	120

The increase in SMY recommended for 1972 and 1977 is encouraging. However, considerable thought must be given to allocation of this support within the total RPA. Using the research categories mentioned in this report, the support for category D (maintaining microbiological safety in handling foods during home and institutional storage and preparation) is poor and should be doubled by 1972 and tripled by 1977. There is some question as to the exact current support level for category A (methods for freeing and protecting breeding herds and flocks from zoonoses) but, nevertheless, it is clear that the Task Force recommends a substantial increase in the effort in this category by 1977. Current support for category C (maintenance of microbial safety in processing, packaging, storing, and distributing foods and feeds) appears to be more realistic and only a slight increase in SMY by 1977 is recommended. Category C received over 70 percent of the available SMY in 1966. The Task Force recommends that by 1977 this effort be decreased to less than 50 percent of the total. The SMY thus released would be distributed to increase the proportional effort in the other categories with the largest increases percentagewise in categories A and D. The final distribution of the 120 SMY projected for 1977 would be approximately as follows: category A - 20, category B - 25, category C - 50, category D - 10, category E - 15.

PREVENT TRANSMISSION OF ANIMAL DISEASES AND PARASITES TO PEOPLE (RPA 707)

The National Program of Research for Agriculture outlined the following objectives of research on transmissible diseases:

A. Full understanding of the mechanism involved in transmission of animal diseases to people.

B. Development of control programs to prevent transmission of animal diseases to people.

C. Development of means of eradicating trichinosis from the U. S.

D. Development of improved procedures, equipment, and facilities for use in red meat and poultry inspection programs.

The Food Safety Task Force was charged with the responsibility of evaluating research and manpower needs for the last mentioned specific problem area, RPA 707-D.

DEVELOPMENT OF IMPROVED PROCEDURES, EQUIPMENT AND FACILITIES FOR USE IN RED MEAT AND POULTRY INSPECTION PROGRAMS (RPA 707-D)

Situation and Current Program: Where there is an animal disease transmissible to human beings or a contamination with human disease-producing organisms, it is essential and urgent that animals and poultry harboring them be identified and removed from food channels or rendered harmless. This cannot always be accomplished with the inspection techniques used today, which rely on signs (or symptoms) at ante-mortem and post-mortem. As in humans, animals also have carriers that do not show signs of a disease and/or disease organism that cannot be seen macroscopically. On the other hand, we must not condemn carcasses unnecessarily. It is essential, therefore, that we must always be upgrading and improving our inspection techniques. To make the best use of our increasing knowledge of diseases in animals and human beings, we must make a proper decision on carcasses as to whether they are hazardous to human health.

The presence of Salmonella or Trichina organisms can be cited as organisms that cannot be detected by present routine inspection techniques.

Many studies discussed elsewhere in this report (RPA 702-C) have an application to RPA 707-D. For example, the studies on the fate of Salmonella during processing of meat and poultry would apply here as well.

Priority Research Needs

1. Increasing efficiency of meat inspection personnel and the effectiveness of procedures

A study by USDA using standard techniques in methods, time, and motion revealed numerous areas where speed and accuracy of inspection procedures could be improved.

2. Equipment and Methodology Aids for Meat Inspectors

A more suitable means of decharacterizing inedible animal products is needed. Further research is needed on electronic equipment to detect the presence of metal particles in boneless meats.

3. Development of objective methods for use in meat inspection

The methods applied in meat inspection are based on sensory evaluation, mechanical, and laboratory diagnoses. Areas needing particular attention are:

a. Broader aspects of meat inspection

The present meat inspection system serves a very useful function by eliminating diseased animals from food channels and recording these disease conditions. The present feedback system should be expanded and perfected to improve preventive measures and reduce disease incidence. An improved animal identification system would enhance the feedback system and aid cooperating agencies to identify a producer in a disease outbreak. Laboratory analysis at the slaughter level for Salmonella and Trichina, under a proper animal identification, could be channeled through the feedback system to a cooperating agency for control and inspection at the production level. Eventually these two disease conditions could certainly be reduced at the food animal production level.

b. Improvements in meat inspection techniques

It is known that the consumers' risk is greater than the producers' in cases of salmonellosis and trichinosis. Improved discrimination at the producers level would result if meat inspection applied laboratory techniques such as those used in the rapid and sensitive detection of human disease conditions by automated laboratory analyses. In meat inspection, the cost of laboratory screening could be reduced by using pooled samples of tissues or blood from 10 or more animals. The individual producers in a positive pool could be recorded with a feedback to a cooperating agency. Laboratory screening would offer additional protection to the consumer and a tremendous source of information for future reference on animals from a producer without creating havoc in the industry.

Manpower Needs. Based on 16 SMY for FY 1966 for all of RPA 707, one may estimate RPA 707-D to have occupied 2 SMY in 1966. We recommend this be increased to 10 in FY 1972 and to 26 in FY 1977. The Consumer and Marketing Service, the Department agency responsible for meat and poultry inspection programs, has advised the Agricultural Research Service of at least 60 problem areas where research efforts are needed.